Cryospheric Applications of LDCM / Landsat-8

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# LDCM / Landsat-8 Cryosphere group

- **Ted Scambos (PI) is a Senior Research Scientist, and Lead Scientist at NSIDC, a part of University of Colorado;** ice sheet mapping, polar field geophysics, climate change in polar regions, sea ice processes

- **Robert Bindschadler (Co-I, contractor) is an emeritus scientist for NASA affiliated with the Cryospheric Sciences group at GSFC**

- **Terry Haran,** senior programmer and geospatial mapping expert, NSIDC
- **Jennifer Bohlander,**data analysis and image processing, NSIDC
- **Patricia Vornberger**, data processing, GSFC contracting firm

- **Allen Pope**, spectral mapping of mountain glaciers; polar remote sensing; **will be a post-doc at NSIDC, Fall 2013**

The National Snow and Ice Data Center ---

Manages and distributes scientific data

Provides tools for data access
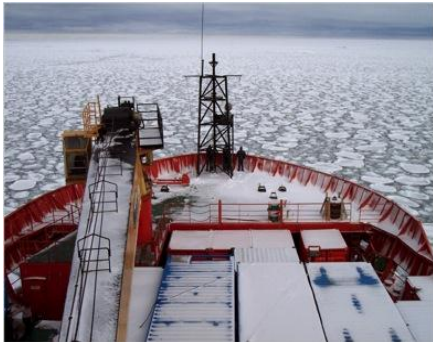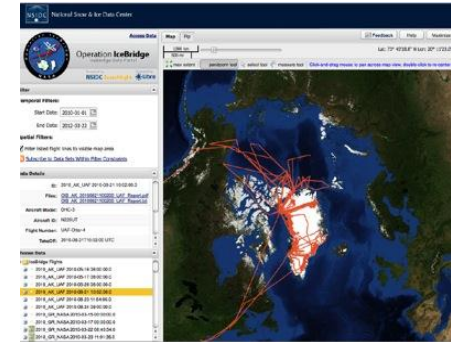
Researches the cryosphere and data science

Supports local and traditional knowledge

Supports data users

Educates the public about the cryosphere

Ice and Remote Sensing

• **Polar regions and high mountain areas are vast, remote, difficult to work in, and changing rapidly.**

• **Remote sensing methods over snow and ice are highly effective**, several proven measurement methods.

— spatial: mapping of ice extent, low-contrast topography, flow-related structures, crevasses, debris cover, snow dunes

— spectral: albedo, snow grain size, blue ice, melt and melt ponds, dust or soot on snow

— thermal: melt onset; ice front ocean; ice sheets in winter

• **The Landsat sensor series represents arguably the best change detection data set in existence for polar ice sheets and glaciers.**
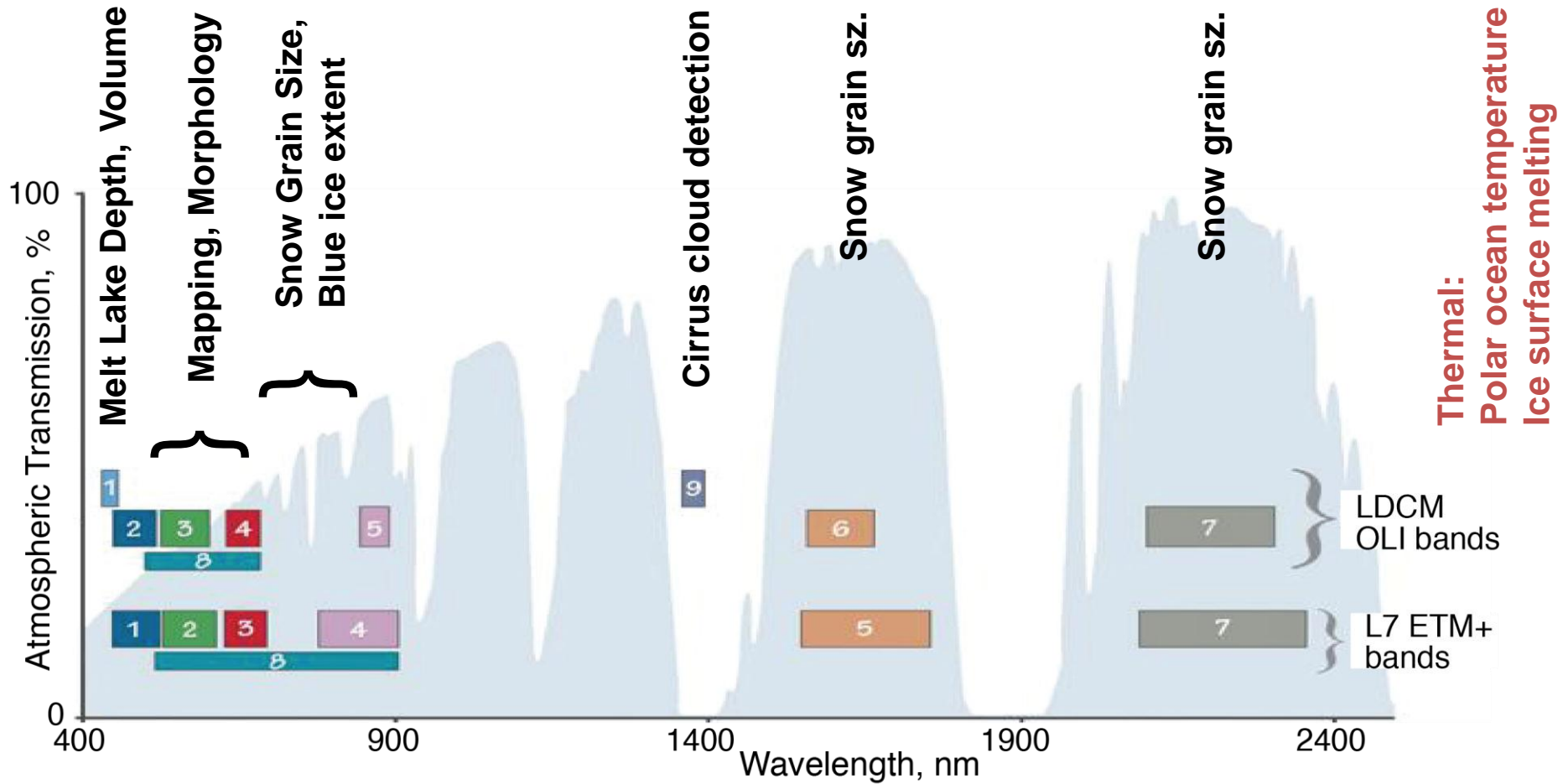
Main Goals

Promote use of Landsat-8 by the polar and glacier communities

Acquire data that supports wide range of science applications

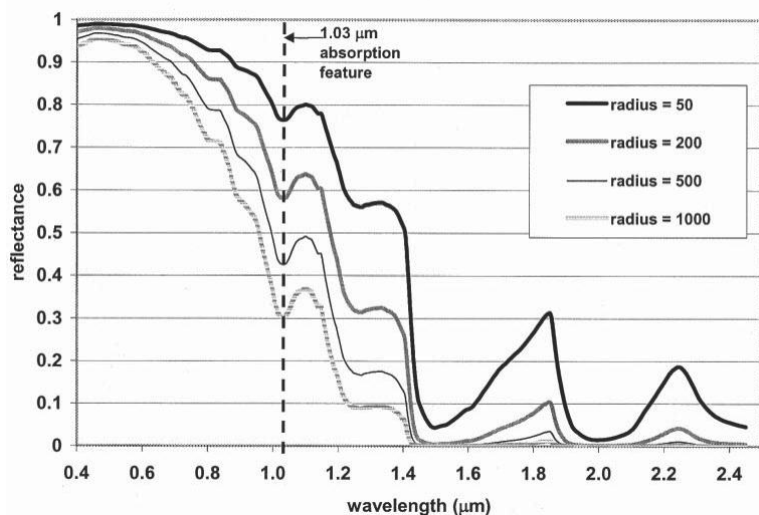Conduct a series of key studies, validate a number of techniques

Demonstrate effectiveness of the Landsat-8 sensors

Snow and Ice and the Landsat 8 bands

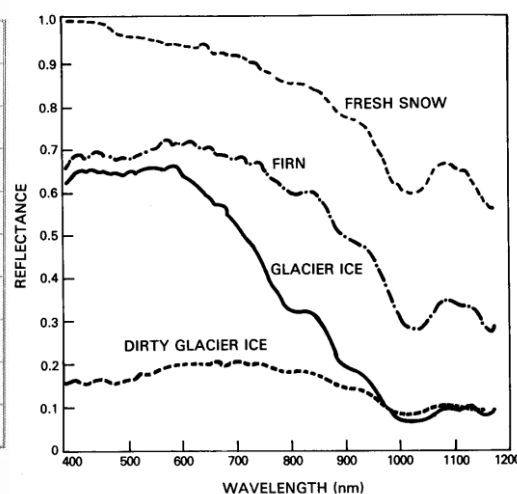B. Markham / NASA GSFC / USGS EROS
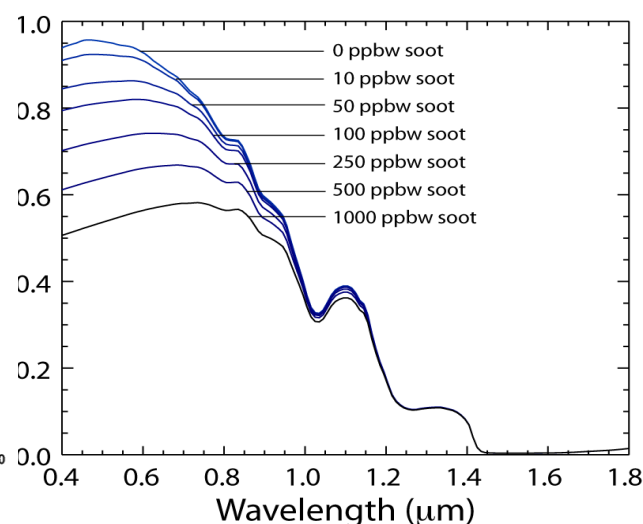
Snow and Ice Spectra in Vis – NIR range

Spectral reflectance of pure snow for varying snow grain size

Snow, ice, and 'dirty snow' spectra

Snow spectra with soot contamination

Excellent LDCM OLI radiometry in visible and near-infrared bands supports spectral measurements of albedo / grain size, snow – ice zone, or dust / soot contamination

Landsat-8 Glacier Applications

polar glaciers

ice front extent, crevasses, ice velocity, summer melt extent, dust or soot(?) *elevation change*

Feature tracking, albedo, ocean therm.

mountain glaciers

Glacier extent beneath debris cover, ice velocity, equilibrium line altitude, dust or soot on snow; elevation change
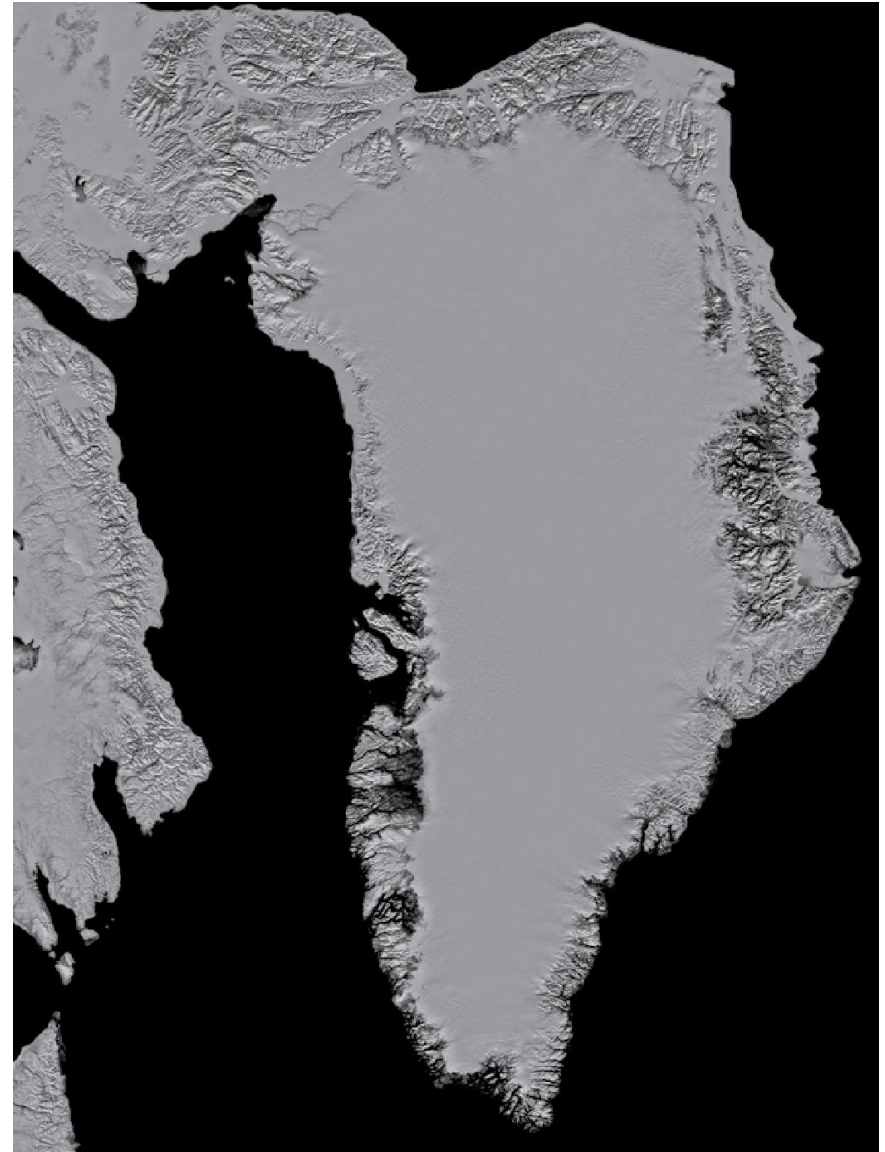
Mapping (w/DEM), thermal data, feat. track.

Landsat-8 Ice Sheet Applications

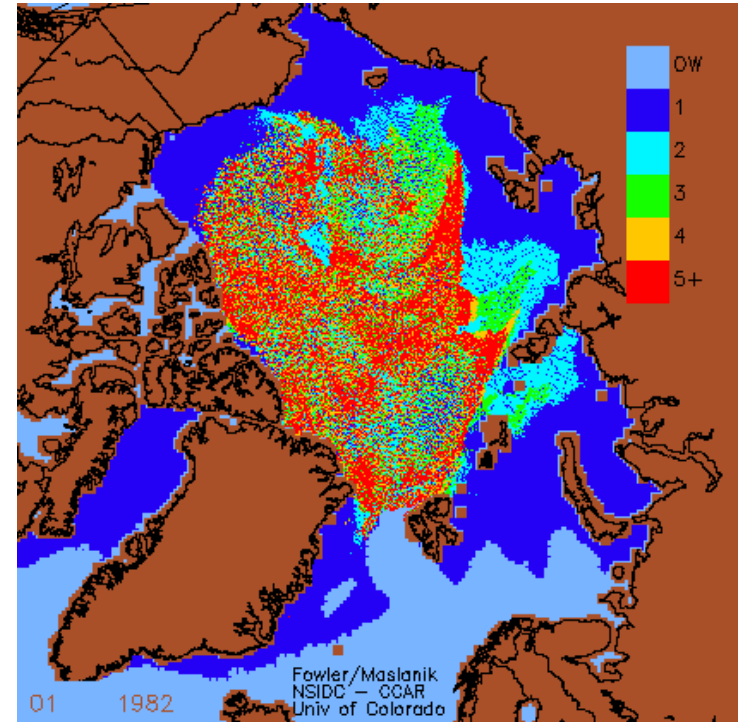Ice edge, floating ice front extent mapping;

Mapping of 'grounding line';

Topography and morphology;

Spectral measurements –
    albedo
    snow grain size
    blue ice extent
    melt extent
    ice sheet zones (facies)

T. Scambos, T. Haran, NSIDC

Landsat-8 and Arctic Sea Ice

- rapid decline due to Arctic warming: sea ice structure, thickness changes

- collect selected area repeatedly to document sea ice type changes, melt ponding

J. Maslanik and C. Fowler, CCAR UCB

Potential LDCM studies

Snow grain size and blue ice extent on ice sheets from LIMA / MOA

Morphology of ice sheets and ice shelves
    (comparison of 'sensitivity' to past sensors)

Feature tracking w/ Landsat legacy comparison

Lake extent, depth, and volume in western Greenland / AP

Image differencing and sub-ice-sheet water movement

Photoclinometry / shape-from-shading at grounding line and
        interior undulation

Thermal mapping of polar ice sheets, winter inversion layer,
        ocean SST at the ice fronts.

# Data structure for change detection of ice sheets / glaciers

Create an 'image stack' subset on path-row regions;
    ~2000 to 2016

– selected bands of Landsat 4, 5, and 7

– selected MODIS daily data

– Landat-8 data

– ancillary files such as DEM, climate data,

Create a Hadoop / MapReduce / 'Data Rods' transformation of the data for the ice sheets.

Supports rapid time-series data extraction for evolution, seasonal cycle, and change detection.

Mapping Antarctica – LIMA (Landsat Image Map of Antarctica)
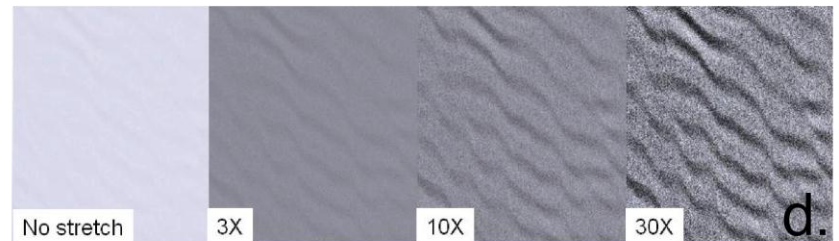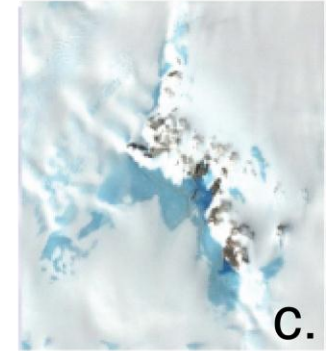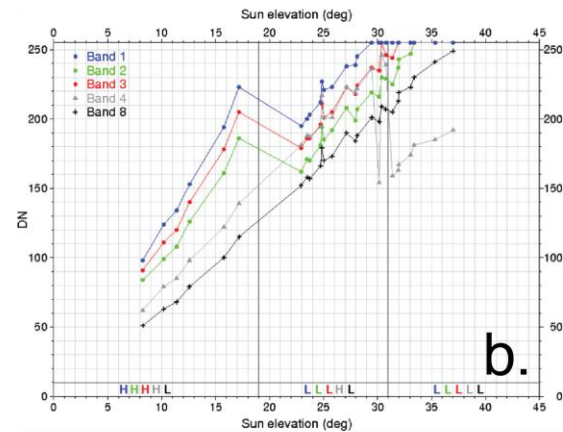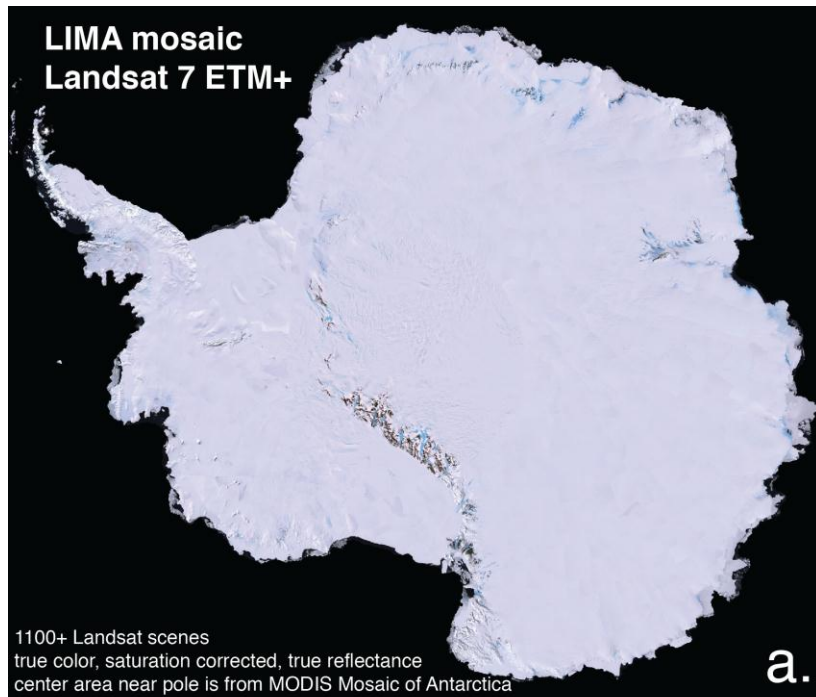
- several further products can be derived from the LIMA data set:
snow grain size, blue ice extent, snow structure mappings (e.g., dunes, flowstripes)

- plan to acquire data to support a Greenland or Arctic-wide LIMA-style mapping

- repeat (LIMA-L8) will support refined mapping, continent-wide change detection

R. Bindschadler et al., 2008

Feature tracking – ice motion from image pairs
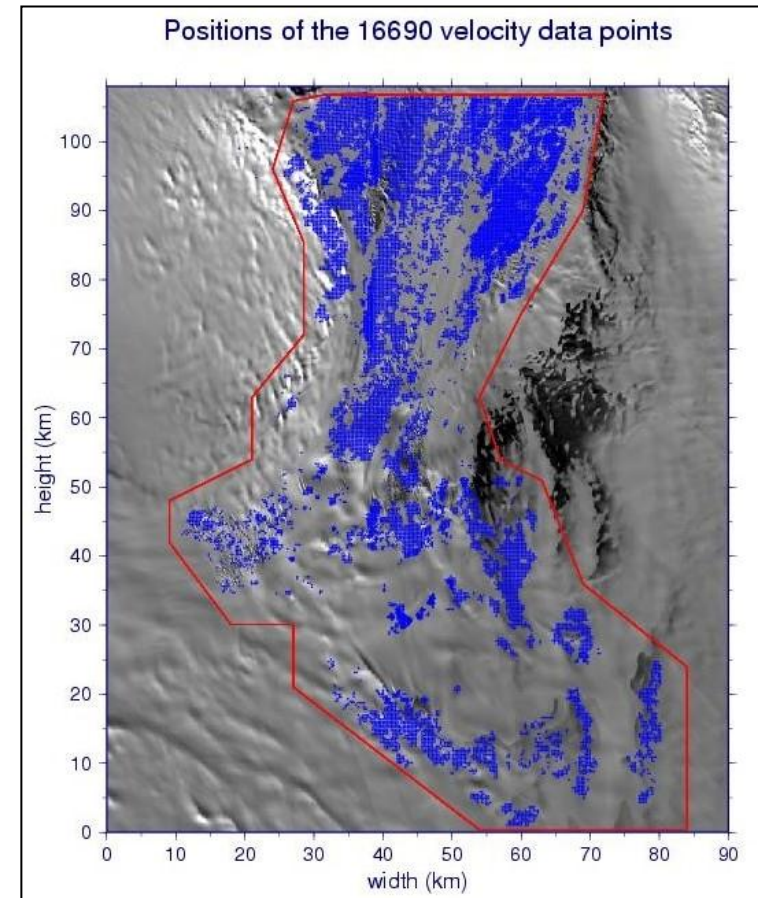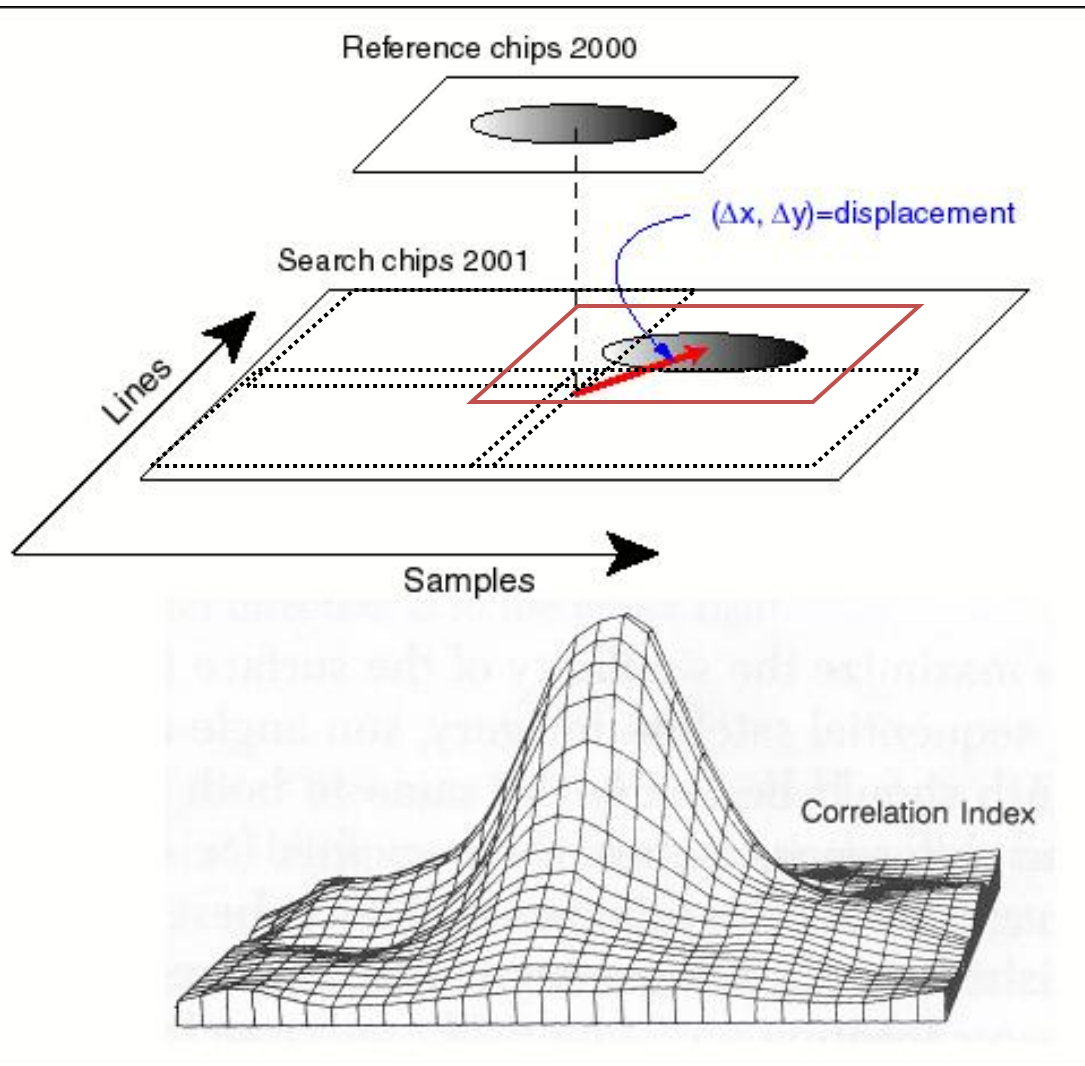
Rapid mapping of ice flow, ice velocity change

T. Scambos et al., 1992; Bindschadler and Scambos, 1991; Berthier et al., 2002
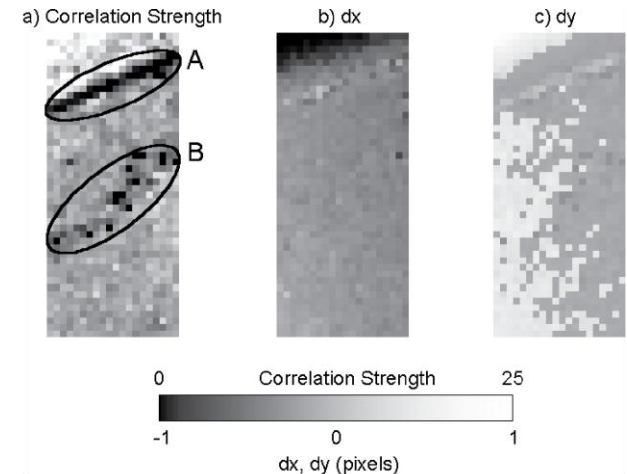
Feature tracking – ice motion from sastrugi 'speckle pattern'?

IKONOS 1m, 11-bit radiometry image of Antarctic snow surface showing sastrugi (small snow dunes).
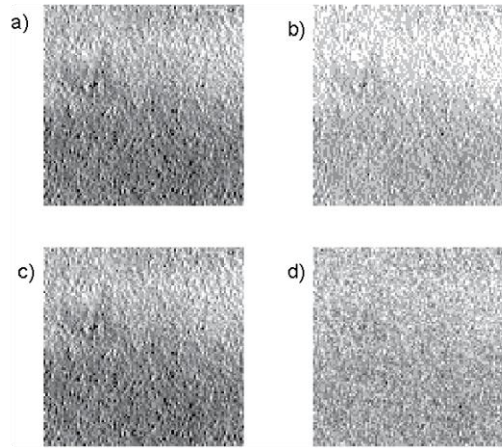
Simulated ALI pancrhomatic (a, c) and Landsat 7 ETM+ (b, d) images of same area (10-m resampling; ± 1 DN noise added in c and d simulations)

Ice motion measurement by feature tracking over similar snow surface using ALI image data: correlation, x displacement, and y displacement

- 12-bit radiometry on Band 8 may be sensitive to sub-pixel structures

- possible to extend ice velocity mapping to regions without crevasses (16-day repeat images, >300 m/yr speed)

Melt ponds on ice sheets – area / volume measurements

Effects of melt ponds:
      acceleration of flow
      enhanced fracturing

Uses new 'Coastal' band
-ratio with red or NIR band

Western Greenland,
Antarctic Ice Shelves
Arctic sea ice

Questions?